Indicator: Pesticide Resistant Arthropod Species (225)

The World Health Organization defines pesticide resistance as "the development of an ability in a strain of insects to tolerate doses of toxicants which would prove lethal to the majority of individuals in a normal population (WHO 2002)." A case of arthropod pesticide resistance is defined as "an arthropod species with documented resistance to a unique pesticide formulation, mixtures or compound in one or more location in the world (Mota-Sanchez, Bills and Whalen)." The occurrence of pesticide resistence in crop pests means that additional types of pesticides or other integrated pest management (IPM) strategies must be applied, with the potential for additional harm to ecological systems.

This indicator is based on data collected by the Center for Integrated Plant Systems & Department of Entomology at Michigan State University, which summarizes reports of pesticide resistance cases from 1914 to the present on the internet. The database reports when the resistance was first discovered for a specific time and place. The arthropod resistance database developed at Michigan State University has tracked peer reviewed cases of resistance where the resistance ratio is 10 or higher. A resistance ratio is a ratio of the dose-mortality of the tested strain to the dose-mortality of a known susceptible strain. LD50 or LC50 values are commonly used. For the time dimension of resistance, the year of the research was used, if included, otherwise the year of submission or the year publication was a surrogate value.

What the Data Show

Between 1950 and 2000, the incidence of new cases of arthropod pesticide resistance in the United States increased from an average of 12 new cases per year in the 1950s to an average of 49 new cases per year in the 1960s and 46 new cases per year in the 1970s (Figure 225-1). The peak years of incidence increase were 166 new cases in 1965 and 146 new cases in 1974 (Mota-Sanchez, 2004). The incidence of new resistance cases decreased to 30 cases per year in the 1980s and increased slightly to 38 new cases per year in the 1990s. The incidence of arthropod pesticide resistance is strongly correlated with the cumulative number of active pesticide ingredients registered by the U.S. Environmental Protection Agency. The Pearson's correlation coefficient between reported resistance cases and the cumulative number of active pesticide ingredients registered by the EPA is 0.97.

Indicator Limitations

- Pesticide resistance is a dynamic, evolutionary phenomena and a record in this database may or may not be indicative of a given region. Similarly, the absence of a record in this database does not indicate absence of resistance in a region.
- Not all submissions in the database clearly document the time of the first appearance of a resistance population in a region, but detect it only after a resistant population has been established.

Data Sources

The database is a compilation of arthropod species (insects, spiders and mites), the pesticides that they are resistant to, when and where in the world the resistance was documented, and a citation of the research paper that documents this resistance. The database of resistance reports cases from 1914 to the present and notes when resistance is first discovered for a specific time and place. The data is based upon continuing review of all available peer reviewed literature as well as a previously published review by G. Gheorghe (UN FAO, 1991). The database can be found at http://www.cips.msu.edu/resistance/rmdb/.

References

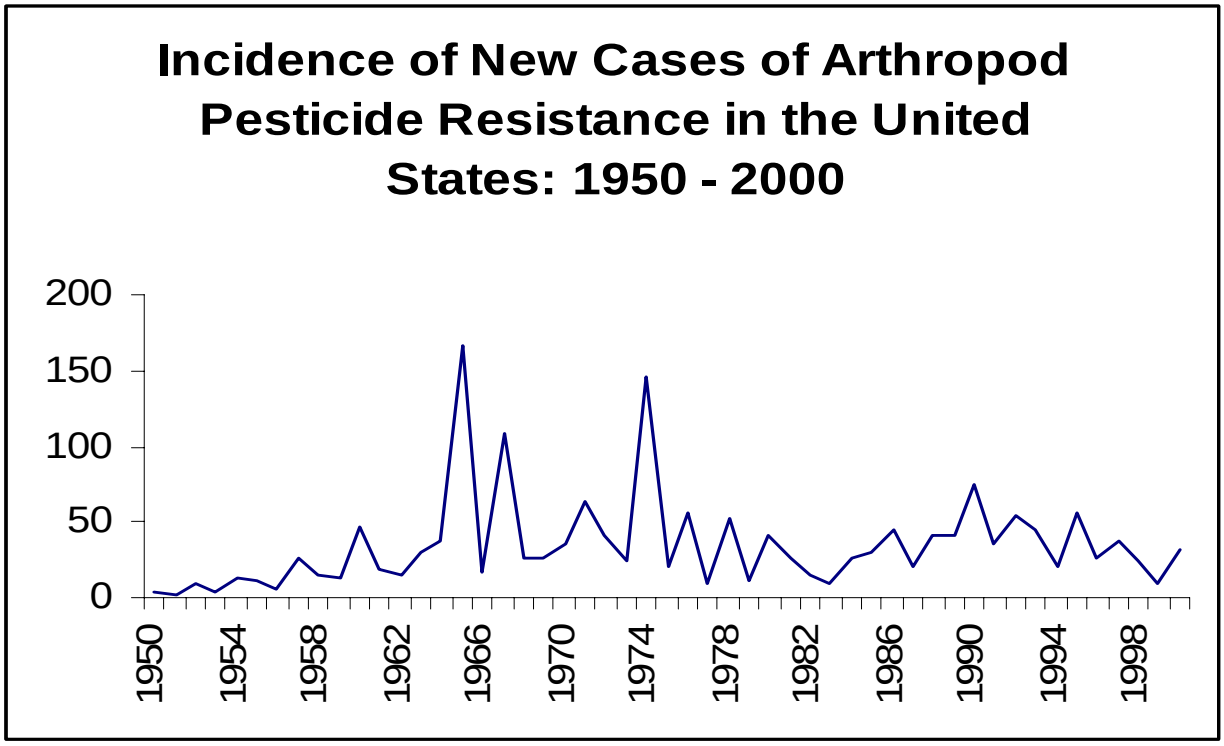
David Mota-Sanchez, PhD, Michigan State University, Center for Integrated Plant Systems, Department of Entomology, 2004

David Mota-Sanchez, Patrick S. Bills, and Mark Whalon, A Database of Arthropods Reported to be Pesticide Resistant- Poster

World Health Organization, Expert Committee on Malaria. 7th Report, WHO Tech. Rep. Ser. 125, 1957 as cited in David Mota-Sanchez, Patrick S. Bills, and Mark Whalon, "Chapter 8 Arthropod Resistance to Pesticides: Status and Overview," Pesticides in Agriculture and the Environment, ed. Willis B. Wheeler, (2002), p 243.

Graphics

Figure 225-1



R.O.E. Indicator QA/QC

Data Set Name: PESTICIDE RESISTANT ARTHROPOD SPECIES
Indicator Number: 225 (89363)
Data Set Source: Michigan State University, Center for Intregrated Plant Systems, Department of Entomology
Data Collection Date: 1914 to present
Data Collection Frequency:
Data Set Description: Pesticide Resistant Arthropod Species
Primary ROE Question: What are the trends in chemicals used on the land and their effects on human health and the environment? (Chemicals to include toxic substances, pesticides, fertilizers, etc.)

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The underlying data are peer reviewed journals documenting cases of arthropod pesticide resistance. The criterion for inclusion is the resistance ratio, a dose-mortality ratio of the tested species to known susceptible species. The ratio is usually in LD50 or LC50.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

The database relies on new reported cases of resistance in peer reviewed journal rather than statistical field collection. For more about the methodlogy of the database's development, see http://www.cips.msu.edu/resistance/rmdb/

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

In reference 1, the authors and managers of the MSU resistance database indicate that, although there are standardized methods documenting resistance detection, authors frequently report and interpret the data differently. The MSU authors relied upon well established measures of LD50, LC50, median lethal time, median knockdown (KD50) and discriminating doses. They used a widely accepted measurement of documenting resistance, the resistance ratio, which compares LD50 values for the resistant population with LD50 values for the susceptible population. The authors define a case of resistance as a documents resistance ratio of 10 or greater in general. Lower resistance ratios are included when there is other evidence to suggest significant resistance. For more about the methodology of the database's development, see http://www.cips.msu.edu/resistance/rmdb.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

This indicator is based on reported cases rather than a statistical sampling design.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The database compiles reported published peer reviewed new cases of pesticide resistance rather field sampling.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

The resistance ratios used as the basis for inclusion in the database are a comparison of dose to mortality of tested strains of pests in comparison to dose to mortality of susceptible strains. A resistance ratio of 10 is generally the cutoff and LC50 or LD50 is usually the dose to mortality measure used in calculating the resistance ratio.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

This indicator is based on reported cases rather than a statistical sampling design.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The complete data set are available online. http://www.cips.msu.edu/resistance/rmdb/

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

NA. This indicator is based on reported cases rather than a statistical sampling design.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

There is no formal QA protocol for existing entries in the data base. For prospective entries, there will be an electronic survey that requires more substantiation.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

This indicator is based on reported cases rather than a statistical sampling design.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

No. For more about the methodlogy of the database's development, see http://www.cips.msu.edu/resistance/rmdb/

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Since pesticide resistance does not have standardized reporting methodologies and because interpretation of the same data and measure (e.g. resistance ratios)vary among researchers, it is difficult to quantify or characterize uncertainty and variability impact. In this database, the resistance ratio (LC50 resistant population/ LC50 susceptable population) of 10 is used to screen cases for inclusion in the database. Sometimes cases with lower resistance ratios are used if there is other strong evidence of resistance.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Since the data in the database are reported new cases rather than a randomly obtained sample of resistant arthropods, it's unlikely a user would mistake the data for national incidence. Just as the numbers of new snakeheads found in the Potomac or the number of new SARS cases don't tell us what the prevalence of these cases are for the whole population.